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Comparison of structural diversity of tree-crop associations in Peripheral and Buffer zones of Gachabari Sal forest area, Bangladesh

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Abstract: The structural diversity of different tree-crop associations were studied at Gachabari Sal forest area of Madhupur Garh on Buffer and Peripheral Zone during 2006. The total density, basal area of trees in the Buffer and Peripheral Zone were 155.5 trees·hm^{-2}, 795.4 trees·hm^{-2} and 3.9 m^2·hm^{-2}, 5.8 m^2·hm^{-2}, respectively. No regeneration and natural trees were found in Peripheral Zone and the Zone is totally occupied by exotic species where the Buffer Zone comprised of both natural and exotic trees. The Peripheral Zone belonged to younger and smaller trees whereas the Buffer Zone belonged to mixture of smaller, taller, younger and mature trees simultaneously. For the practicing of different agroforestry systems both Zones have lost their original characters of Sal forest.

Keywords: Structural diversity, Tree-crop associations, Sal, Peripheral and Buffer Zone.

Introduction

The traditional Sal forests of Bangladesh belong to the category of tropical moist or dry deciduous forest (Rashid *et al.* 1995). Available information suggests that currently only 10% of the 120 000 hm^2 of Sal forests are covered with Sal trees (Gain 1998). The Madhupur Sal forest is the largest patch, which plays a vital role in maintaining ecological balance at the centre of the country. But unfortunately this forest area is degraded, denuded and encroached to such an extent that it has lost the main features of the original Sal (Rashid and Mia 2001). The worst destruction of wildlife and biodiversity has also taken place in the Sal area. Traditional Sal forest has now becoming a history for introducing commercial cultivation and adoption of exotic plant species. In the core zone of Mahupur Sal forest some natural species can be found but it is declining day by day and after few decades it will be a funny story. Now –a-days the Buffer and Peripheral Zone of Madhupur Sal forests have become a history of natural Sal forest. The recurrent anthropogenic disturbances have rendered the system inhospitable for the regeneration and growth of wild plant associates, causing a net loss in plant diversity (Pande 1999). Being a land-hungry country, Bangladesh cannot preserve her forest areas due to severe pressure on forest land by overpopulation. Agroforestry has become an effective tool to replenish degradation of forest as it offers direct benefits to the local community from its early stage of establishment. Government of Bangladesh and Non-Government Organizations launched several agroforestry projects throughout the country including Madhupur Sal Forest.

Most of the studies on Indian Sal forests are concerned with vegetation analysis of *Shorea* communities (Gupta and Shukla 1991; Singh *et al*. 1995; Pande 1999; Pandey and Shukla 1999). In Bangladesh there are some lists of plants found in Sal Forest areas (Alam 1995; Choudhury *et al*, 2004; Rashid and Mia 2001). No detailed studies on plant diversity of Sal forests in Bangladesh are also available (Alam 1995). The present study was, therefore, undertaken to assess the structural diversity with emphasis on stand structure including vertical and horizontal structure of Peripheral and Buffer Zone and to compare the degree denudation of natural trees between these two zones.

Materials and methods

The study was conducted at Gachabari area under Madhupur Garh, Bangladesh. The area is located between 23º50'–24º50' North latitude and 89º54'–90º50' East longitude with 15 m altitude and the climate of the region is moderate. The annual rainfall ranges from 1500 to 2100 mm and the temperature ranges from 10 to 34ºC. The soil is red brown terrace with low organic matter content and moderately to strongly acidic in reaction (Richards and Hassan 1988). The study was carried out during November/2006. The Gachabari Sal forest area may be classified in three zones: (1) the peripheral zone, consisting of exotic tree stands with different field crops (2) the buffer zone, consisting of few natural Sal-exotic tree stands with different field crops and (3) the core zone, consisting of coppiced Sal.

For the present study we have established 30 circular plots of 300 m^2 area in the Peripheral and Buffer Zone respectively. Plots of Peripheral Zone were established randomly from different sites and plots from Buffer Zone were established continuously at 100

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m interval in any directions. For the purpose of describing the stand structure the diameter at breast height (DBH), height and trunk height of each tree (≤ 5cm d.b.h. and ≤1.37 m height) were measured for each individual on each plot. The vegetation was quantitatively analyzed by frequency, density and basal area of trees following Curtis and McIntosh (1950). The relative values of frequency, density and abundance were determined as per Phillips (1959). These values were summed to represent IVI (Importance value Index) of individual species (Curtis 1959). Diameter of tree populations was classified as ≥5–10 cm, 10.1–15 cm, 15.1–20 cm, 20.1–25 cm and >25 cm where height was classified as ≥1.37–5 m, 5.1–10 m, 10.1–15 m, 15.1–20 m and 20.1–25 m. Each tree was classified according to its status as a dominant, co dominant, intermediate and suppressed tree on the basis of crown length, tree height, side branching and general level of canopy crown.

Results

Phytosociology

In the Peripheral Zone only exotic tree species (04 species) and no natural tree species was found. In the Buffer Zone 02 natural tree species and 03 exotic tree species were found (Table 1). In both zones different agroforestry systems were observed. Therefore 05 crop species in the Buffer Zone and 07 crop species in the Peripheral Zone had various associations with tree species (Table 1). The mean density per hectare of individuals of ≥5 cm d.b.h. was maximum for Sal (97.8), followed by Mangium (40.5), Acacia (10.8), Arjun (6) and Bohera (0.6) in the Buffer Zone the maximum was found for Acacia (304.4), followed by Gamari (276.6), Bokain (193.3) and Mangium (21.1) in the Peripheral Zone (Table 2). Considering all tree species Buffer Zone indicates a density of 155.7 trees·hm^{-2} which was 20% of Peripheral Zone (795.4 trees·hm^{-2}) (Table 3). Total basal area of Buffer Zone was 3.9 m^2·hm^{-2} which was 67% of Peripheral Zone (5.9 m^2·hm^{-2}) (Table 3). In the Buffer Zone, the natural tree species Bohera belonged to 0.7% relative density though its relative basal area is 20.7%. Considering density and basal area of trees of both Zones it can be concluded that within the Buffer Zone mature trees with higher diameter and in the Peripheral Zone younger trees with lower diameter exists. Among all natural tree species, Bohera in the Buffer Zone had the highest basal area. The maximum Important Value Index was found for Acacia (108.5) in Peripheral Zone and for Sal (171.5) in Buffer Zone (Table 2). Sal was found to be present as the main associated species in the Buffer Zone while Acacia in the Peripheral Zone. Regeneration of Sal (146.7 seedlings·hm^{-2}) was found only in Buffer Zone and no regeneration was observed in Peripheral Zone (Table 2). No saplings (>30cm height) were found in the Buffer Zone.

Table 1. Different tree-crop associations (agroforestry systems) found in the study area

Aspect	Tree-Crop Associations	No. of natural tree species	No of exotic tree species	No. of crop species
Buffer Zone	1. Sal+Acacia—Pineapple+ Mustard	02	03	05
	2. Sal+Acacia—Pineapple+Papaya			
	3. Sal+Acacia— Pineapple+Banana			
	4. Sal+Acacia— Pineapple+Banana+Papaya			
	5. Sal+Mangium— Pineapple+Papaya			
	6 .Sal+Mangium— Pineapple+Banana			
	7. Sal+Mangium— Pineapple+Banana			
	8. Sal+Mangium+Acacia— Pineapple+Banana			
	9. Sal+Mangium+Acacia— Pineapple+Papaya			
	10.Sal+Mangium+Acacia— Pineapple+Banana+Papaya			
	11. Sal+Arjun+Acacia—Cotton			
	12.Sal+Bohera+Acacia+Manjium— Pineapple+Banana+Papaya			
Peripheral Zone	1.Acacia—Pineapple	0	04	07
	2.Acacia—Pineapple+Turmeric			
	3.Gamari—Pineapple			
	4.Gamari—Pineapple+Turmeric			
	5.Acacia+Gamari—Pineapple			
	6.Acacia+Gamari—Pineapple+Turmeric			
	7.Acacia—Bitter gourd			
	8.Acacia—Kachu+Ginger			
	9.Acacia—Banana+Papaya			
	10.Acacia—Banana			
	11.Bokain+Mangium+Acacia— Pineapple+Turmeric			
	12. Bokain+Mangium+Acacia— Pineapple+Ginger			
	13. Bokain+Mangium+Acacia— Pineapple+Turmeric+Ginger			

Diameter distributions of tree populations

Diameter class distribution of Buffer Zone indicated that 46.2 % of the total number of trees was of the size ranging from ≥ 5cm cm to 10.0 cm in diameter followed by 15.1 cm to 20 cm diameter (32.6%), and in the Peripheral Zone 65.4% trees was of the size ranging from ≥ 5 cm to 10.0 cm in diameter followed by 10.1 cm to 15 cm diameter (31.8%) (Fig. 1). 7.6% of all individuals belong to the diameter class 10.1–15cm in the Buffer Zone and 2.7% of all individuals belong to the diameter class 15.1–20 cm in the Peripheral Zone. 13.1% population of Buffer zone was of the diameter class 20.1–25 cm whereas only 0.1% population of Peripheral Zone was of that diameter class. Within the range of ≥5–15 cm diameter 53.8% population of Buffer Zone and 97.2% population of Peripheral Zone were found.

Table 2: Frequency (F), relative frequency (RF), density (D), relative density (RD), basal area (BA), relative basal area (RBA) and Important Index Value (IVI) of different tree species in Buffer Zone and Peripheral Zone of Gachabari Sal Forest area

Species		Aspect	F (%)	RF (%)	D (tree·hm^{-2})	RD (%)	BA (m^2·hm^{-2})	RBA (%)	IVI
1. natural	Sal	Buffer Zone	96.7	42.3	97.8	38.3	2.6	66.4	171.5
	Bohera		3.7	1.6	0.6	0.4	0.8	20.7	22.7
2. Exotic	Arjun		14.8	6.5	6	3.9	0.1	3	13.4
	Mangium		76.7	33.5	40.5	26	0.3	7.8	67.3
	Acacia		36.7	16.1	10.8	6.9	0.1	2.1	25.1
Regeneration									
1. 0–30cm height Sal			70	100	146.7	100	-----	------	-------
2. 30.1−130cm height			------	-----	------	------	-----	------	-------
3. >130cm height(<5cm dbh)			------	-----	------	------	-----	------	-------
1. Natural		Peripheral Zone							
2. Exotic	Gamari		36.7	26.2	276.6	34.7	2.2	38	98.9
	Mangium		20	14.3	21.1	2.7	0.1	2	19
	Acacia		50	14.3	304.4	38.3	2	34.5	108.5
	Bokain		33.3	35.7	193.3	38.3	1.5	25.5	73.6
	Regeneration		------	-----	--------	------	------	------	-------

Table 3. Mean of density and basal area of all tree species in Buffer and Peripheral Zone

Aspect	Mean density	Mean basal area	Ratio of Density (Buf: Peri)	Ratio of basal area (Buf: Peri)
Buffer Zone	155.7	3.9	0.2	0.67
Peripheral Zone	795.4	5.8		

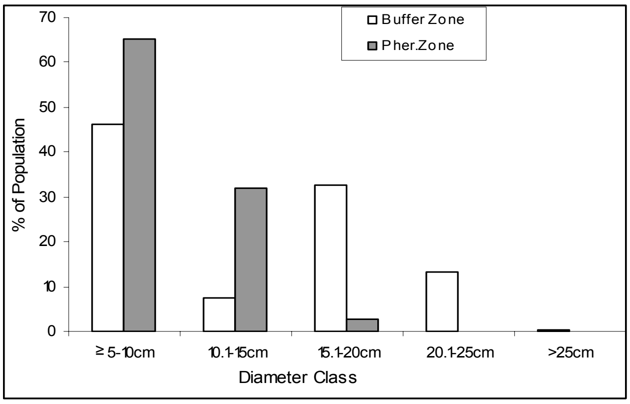

Fig. 1 Diameter class distribution of tree populations of the study area

Height class distribution

The height class 15.1–20 m belonged to maximum population (38.5%) followed by 5.1–10 m height class in the Buffer zone where 5.1–10 m height class belonged to maximum population(53.1%) followed by 10.1–15.1 m height class in the Peripheral Zone(Fig. 2). 15.1–20 m height class in the Peripheral Zone contained 6.5% population and 10.1–15.1 m height class in the Buffer Zone contained 18.5% population. 7.1% population was of the height class 20.1–25 m in the Buffer zone whereas no population found in that height class in the Peripheral Zone. Within the range 15.1–25 m height only 6.5% was found in Peripheral Zone where 45.6% population found in Buffer Zone.

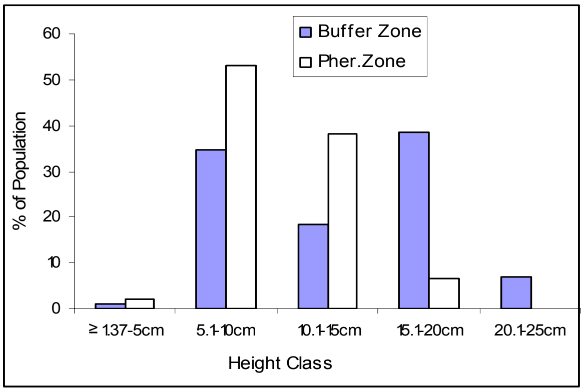

Fig. 2: Height class distribution of tree population in the study area

Crown class distribution

46.8% of all trees in the Buffer Zone have been assed as dominant, followed by co dominant (23.9%), intermediate (19%) and suppressed (10.3%). 33.2% of total trees in the Peripheral Zone have been assessed as dominant, followed by co dominant (31.1%), intermediate (23.6%) and suppressed (12.1%) (Fig. 3).

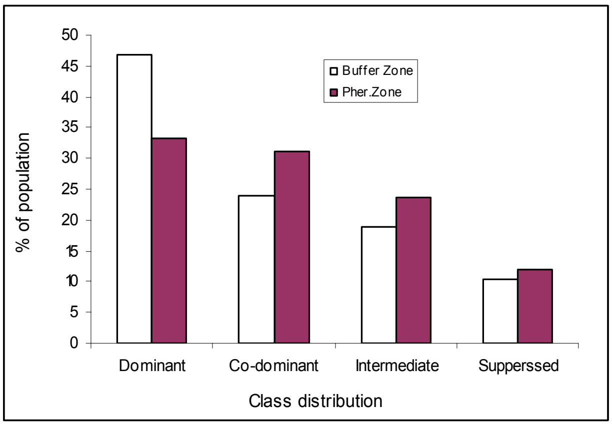

Fig. 3 Crown class distribution of tree populations in the study area

Discussion

All natural species were totally removed and exotic tree species occupied the Peripheral Zone. With the practicing crop productions in the forest areas, both the zones have lost their original characteristics. The results showed that Peripheral Zone has a less density of tree species than the Buffer Zone. Webb and Sah (2003) recorded average densities of 252.5 Sal trees·hm^{-2} for natural forests and 778.3 Sal trees·hm^{-2} for successional Sal forests in Nepal where Pandey and Shukla (2003) recorded the mean density of 304 Sal trees·hm^{-2} in a managed Sal forest in India. Jashiruddin *et al* (1999) reported 1353 Sal stems·hm^{-2} for the coppiced Sal forest in Bangladesh. The density of Sal trees in Buffer Zone appeared to be very scarce for denudation and degradation. Bhuiyan (1994) found 614 exotic trees·hm^{-2} in alley cropping where we found 795.4 exotic trees·hm^{-2} in the Peripheral Zone.

The result showed that the Peripheral Zone belongs to no longer suitable condition for regeneration and the Buffer Zone belongs to few saplings. The seedlings in the Buffer Zone may not attain the size of saplings due to high degradation and cultivation of crops within the tree space. Webb and Sah (2003) recorded average densities of 1 763 saplings·hm^{-2} for natural forests and 1 326 saplings·hm^{-2} for successional Sal forests in Nepal. Nath et al (2005) reported that in the highly disturbed stand, ploughing and clearing of ground vegetation for cultivation practices, firewood collection and grazing together with the below ground competition of mature trees and other plants increase the mortality rate of seedlings and saplings. Peripheral Zone was denser than that of Buffer Zone but in the Peripheral Zone all natural species, regeneration and natural conditions have been disappeared. The basal area of trees of Buffer Zone was greater than that of Peripheral Zone considering density of trees.

The Peripheral Zone indicated J-shaped pattern in which number of stems decrease with the increase of diameter, on the other hand, in the Buffer Zone the d.b.h. class is not J-shaped (Fig. 1). The diameter class distribution indicated that almost trees in Peripheral Zone were younger and a big portion of populations (47.2%) of Buffer Zone were mature and larger in size. For the presence of few natural trees the Buffer Zone belongs to many mature trees. The height class distribution showed that almost trees were smaller in height in the Buffer Zone where Buffer Zone comprised of smaller and taller trees (Fig. 2). Exotic trees in both zones were younger, which were shorter than natural trees of Buffer Zone. In both Zones the crown class distribution follow J-shaped pattern (Fig. 3). The number of dominant trees in Buffer Zone is greater than that of Peripheral Zone due to the presence of higher natural trees.

Conclusions

The Buffer Zone is highly degraded and denuded as only few natural tree species exist there. Crop cultivations within the forest enhanced losing of the original characters of Sal forest in both zones though few decades ago they were natural forests. The Peripheral Zone was comprised of only exotic species of younger and smaller in size whereas the Buffer Zone comprised of both natural and exotic tree species of mixture of younger, mature, taller and smaller trees simultaneously. In Buffer Zone few seedlings of Sal were found which could not attain saplings due to probably soil disturbances and crop cultivations. Recovery of Peripheral Zone could not be possible but the Buffer Zone could be by adopting *in- situ* conservation of seedlings, protecting further denudation; stopping plantation of exotic trees and crop cultivations.

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